FORM PTO-1390 (REV! 5-93)	U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTORNEY'S DOCKET NUMBER **2345/159** :

**TRANSMITTAL LETTER TO THE UNITED STATES
DESIGNATED/ELECTED OFFICE (DO/EO/US)
CONCERNING A FILING UNDER 35 U.S.C. 371**

U.S. APPLICATION NO. (If known, see 37 CFR 1.5)

09/890597

INTERNATIONAL APPLICATION NO. PCT/EP00/00320	INTERNATIONAL FILING DATE **17 January 2000** **(17.01.00)**	PRIORITY DATE CLAIMED: **03 February 1999** **(03.02.99)**

TITLE
REDUCTION OF THE DISTORTION OF OPTICAL IMPULSES THROUGH POLARISATION MODE DISPERSION IN OPTICAL TRANSMISSION SYSTEMS

APPLICANT(S) FOR DO/EO/US
DULTZ, Wolfgang; BERESNEV, Leonid; FRINS, Erna; KUEPPERS, Franko; SCHMITZER, Heidrun; VOBIAN, Joachim; and WEIERSHAUSEN, Werner

Applicant(s) herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.

2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.

3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)) immediately rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).

4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.

5. ☒ A copy of the International Application as filed (35 U S C. 371(c)(2))

   a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).

   b. ☒ has been transmitted by the International Bureau.

   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)

6. ☒ A translation of the International Application into English (35 U.S C. 371(c)(2)).

7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))

   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).

   b. ☐ have been transmitted by the International Bureau.

   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.

   d. ☒ have not been made and will not be made.

8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).

9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)). (UNSIGNED)

10. ☒ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.

12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3 28 and 3.31 is included.

13. ☒ A **FIRST** preliminary amendment.

   ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.

14. ☒ A substitute specification and a marked up version of the substitute specification.

15. ☐ A change of power of attorney and/or address letter.

16. ☒ Other items or information: International Search Report; International Preliminary Examination Report; and Form PCT/RO/101.

Express Mail No.: EL244503832

U.S. APPLICATION NO. if known, see 37 CFR 1 **09/890597**	INTERNATIONAL APPLICATION NO PCT/EP00/00320	ATTORNEY'S DOCKET NUMBER 2345/159

17. ☒ The following fees are submitted:

Basic National Fee (37 CFR 1.492(a)(1)-(5)):

Search Report has been prepared by the EPO or JPO $860.00

International preliminary examination fee paid to USPTO (37 CFR 1.482) $690.00

No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) $710.00

Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO $1,000.00

International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) $100.00

	CALCULATIONS	PTO USE ONLY
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 860	
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$	

Claims	Number Filed	Number Extra	Rate		
Total Claims	12 - 20 =	0	X $18.00	$0	
Independent Claims	2 - 3 =	0	X $80.00	$0	
Multiple dependent claim(s) (if applicable)			+ $270.00	$	

TOTAL OF ABOVE CALCULATIONS =	$860	
Reduction by 1/2 for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 CFR 1.9, 1.27, 1.28).	$	
SUBTOTAL =	$860	
Processing fee of $130.00 for furnishing the English translation later the ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +	$.	
TOTAL NATIONAL FEE =	$860	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property +	$	
TOTAL FEES ENCLOSED =	$860	
	Amount to be refunded charged	$ $

a. ☐ A check in the amount of $_____ to cover the above fees is enclosed.

b. ☒ Please charge my Deposit Account No. _11-0600_ in the amount of _$860.00_ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. _11-0600_. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

By: _____ Reg No 35952

SIGNATURE

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8/3/01
DATE

CUSTOMER NO. 26646

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2345/159

EXPRESS MAIL CERTIFICATE

"EXPRESS MAIL" MAILING LABEL NUMBER *EL 2445038 32*

DATE OF DEPOSIT *8/3/01*

TYPE OF DOCUMENT *Nat'l Phase App. of Dultz's et.al.*
"Reduction of the Distortion of optical Impulses..."

SERIAL NO. *To be Assigned* FILING DATE *Herewith*

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[2345/159]

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s) : Wolfgang DULTZ et al.

Serial No. : To Be Assigned

Filed : Herewith

For : REDUCTION OF THE DISTORTION OF OPTICAL IMPULSES THROUGH POLARISATION MODE DISPERSION IN OPTICAL TRANSMISSION SYSTEMS

Art Unit : To Be Assigned

Examiner : To Be Assigned

Assistant Commissioner
for Patents
Washington, D.C. 20231

PRELIMINARY AMENDMENT AND
37 C.F.R. § 1.125 SUBSTITUTE SPECIFICATION STATEMENT

SIR:

Please amend without prejudice the above-identified application before examination, as set forth below.

IN THE TITLE:

Please replace the title with the following:

--REDUCING THE DISTORTION OF OPTICAL PULSES CAUSED BY POLARIZATION MODE DISPERSION IN OPTICAL COMMUNICATION SYSTEMS--.

IN THE SPECIFICATION AND ABSTRACT:

In accordance with 37 C.F.R. § 1.121(b)(3), a Substitute Specification (including the Abstract, but without claims) accompanies this response. It is respectfully requested that the Substitute Specification (including Abstract) be entered to replace the Specification of record.

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The Substitute Specification reflects the text of Revised Pages 1, 2, 2a, 2b, 16, 17, and 18, associated with the International Preliminary Examination Report.

IN THE CLAIMS:

Without prejudice, please cancel original claims 1 to 12 in the original application and please cancel substitute claims 1 to 12 from the Revised Pages, and please add new claims 13 to 24 as follows:

13. (New) A method for reducing distortion of an optical pulse contained in a communication-transmitting luminous flux in an optical communication system caused by polarization mode dispersion, comprising:

driving a polarization-controlling device to adjust a polarization of the optical pulse so that a transmission quality of the optical communication system is maximized, wherein the driving of the polarization-controlling device functions in response to the transmission quality detected; and

using a small, coupled-out portion of the communication-transmitting luminous flux to determine the transmission quality of the optical communication system.

14. (New) The method of claim 13, further comprising:

resetting the polarization of the optical pulse in predefined time intervals for optimizing communication.

15. (New) The method of claim 13, wherein the polarization of the optical pulse is controlled at an input end of the optical communication system.

16. (New) The method of claim 13, further comprising:

altering the polarization of the optical pulse at an output end of the optical communication system using the polarization-controlling device,

wherein the optical pulse propagates through an analyzer following the optical communication system.

17. (New) An optical communication system having reducible distortion of an optical pulse propagating through the optical communication system and contained in a communication-transmitting luminous flux, comprising:

an optical transmission medium for transmitting the optical pulse;

a determining device to determine a transmission quality of the optical communication system, the determining device having an output;

a polarization-controlling device;

a regulating device having an input;

a beam splitter for coupling out and supplying a small portion of the communication-transmitting luminous flux to the determining device;

wherein a signal from the output of the determining device is applied to the input of the regulating device, and

wherein the regulating device is configured to drive the polarization-controlling device for changing a polarization of the optical pulse so that the transmission quality is optimized.

18. (New) The optical communication system of claim 17, wherein the polarization-controlling device is disposed at the input of the optical transmission medium.

19. (New) The optical communication system of claim 17, further comprising:

an analyzer, the analyzer being disposed in a propagation direction of a light, downstream from the polarization-controlling device; and

wherein the polarization-controlling device is disposed at the output of the optical transmission medium.

20. (New) The optical communication system of claim 17, wherein the polarization-controlling device includes a first $\lambda/4$ delay element, a $\lambda/2$ delay element and a second $\lambda/4$ delay element, the first $\lambda/4$, $\lambda/2$ and second $\lambda/4$ delay elements being disposed in series as $\lambda/4$-$\lambda/2$-$\lambda/4$ and being adjustable.

21. (New) The optical communication system of claim 19, wherein the analyzer is a linear analyzer, and the polarization-controlling device includes at least an adjustable $\lambda/4$ delay element and an adjustable $\lambda/2$ delay element.

22. (New) The optical communication system of claim 21, wherein at least one delay element includes a liquid crystal element.

23. (New) The optical communication system of claim 21, wherein at least one delay element includes an electro-optical crystal.

24. (New) The optical communication system of claim 21, wherein at least one delay element includes at least one of a mechanically adjustable element, an electromotively adjustable element and a piezoelectrically adjustable element of three fiber loops.

REMARKS

This Preliminary Amendment cancels without prejudice original claims 1 to 12 and substitute claims 1 to 12 in the underlying PCT Application No. PCT/EP00/00320, and adds without prejudice new claims 13 to 24. The new claims conform the claims to U.S. Patent and Trademark Office rules and do not add new matter to the application.

In accordance with 37 C.F.R. § 1.121(b)(3), the Substitute Specification (including the Abstract, but without the claims) contains no new matter. The amendments reflected in the Substitute Specification (including Abstract) are to conform the Specification and Abstract to U.S. Patent and Trademark Office rules or to correct informalities. As required by 37 C.F.R. § 1.121(b)(3)(iii) and § 1.125(b)(2), a Marked Up Version Of The Substitute Specification comparing the Specification of record and the Substitute Specification also accompanies this Preliminary Amendment. In the Marked Up Version, shading indicates added text and bracketing indicates deleted text. Approval and entry of the Substitute Specification (including Abstract) is respectfully requested. The Substitute Specification reflects the text of Revised Pages 1, 2, 2a, 2b, 16, 17, and 18, associated with the International Preliminary Examination Report.

The underlying PCT Application No. PCT/EP00/00320 includes an International Search Report, dated May 10, 2000. The Search Report includes a list of documents that were uncovered in the underlying PCT Application. A copy of the Search Report accompanies this Preliminary Amendment.

The underlying PCT Application No. PCT/EP00/00320 also includes an International Preliminary Examination Report, dated April 6, 2001, and an annex (including substitute claims 1 to 12 and the specification text of Revised Pages 1, 2, 2a, 2b, 16, 17, and
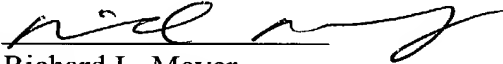
18, associated with the International Preliminary Examination Report). An English translation of the International Preliminary Examination Report and of the annex accompanies this Preliminary Amendment.

Applicants assert that the subject matter of the present application is new, non-obvious, and useful. Prompt consideration and allowance of the application are respectfully requested.

Respectfully Submitted,

KENYON & KENYON

By: _~~~~~~_

Dated: 8/3/01

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REDUCING THE DISTORTION OF OPTICAL PULSES
CAUSED BY POLARIZATION MODE DISPERSION IN OPTICAL
COMMUNICATION SYSTEMS

FIELD OF THE INVENTION

The present invention relates to a method for reducing the
distortion of optical pulses in optical communication systems,
and to an optical communication system having reduced

5   spreading of the optical pulses propagating through the
system.

BACKGROUND INFORMATION

In optical communications, optical components, such as optical

10   elements and glass fibers, which are only isotropic in the
first approximation or which are innately anisotropic are
believed to be used. For example, the glass fibers employed in
photonic networks may exhibit optical anisotropies due to the
manufacturing process and design or due to other

15   circumstances, such as temperature and pressure fluctuations,
as well as because of the bending of the fiber itself. These,
in part, location-dependent anisotropies may also produce an
optical birefringence (or double refraction), which can also
vary from location to location in the fiber. The birefringence

20   (or double refraction) may result in two orthogonally
polarized natural waves of the light propagating at a
different phase velocity in one fiber section under
consideration. When an optical signal, e.g., an optical pulse
having any polarization, is transmitted through the fiber, the

25   optical pulse is believed to become distorted, i.e., spreads
during the course of propagation, due to the difference in the
velocity of the various polarization components. This
spreading of the optical pulses may limit the transmission
rate in the communication system.

30

The reference of "Optical Equalization of Polarization

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Dispersion", J.H. Winters et al., Proceedings of the STIE, January 1, 1992, discusses an optical equalizing system, which can be used to reduce the influences of polarization mode dispersion. It is believed that to generate the control

5   signals for the polarization-controlling elements, the optical received signal is received in its entirety in one or a plurality of receivers and is analyzed accordingly. A further transmission of the optical signal is believed to be no longer possible.

10

The U.S. Patent No. 5,793,511 discusses an optical receiver having an equalizing circuit which is able to equalize an optical signal distorted by polarization mode dispersion. For this, the received optical signal is converted into two

15   electrical components, of these, the equalizing circuit generating a quality signal for driving a polarization control element implemented in the receiver.

The European Patent Publication No. 0 716 516 discusses a

20   polarization-diversity detection technique for optical signals transmitted over a single-mode fiber. To compensate for distortions caused by polarization mode dispersions in the fiber, a polarization-diversity detection is carried out. For this, it is believed that the optical received signal is

25   initially separated by a polarization beam splitter into a first and second polarization component. A control signal is believed to be subsequently generated to control a polarization-control element as a function of the phase difference between the two polarization components.

30

SUMMARY OF THE INVENTION
An exemplary embodiment of the present invention is directed to providing a method for reducing the distortion of optical pulses in optical communication systems caused by polarization

35   mode dispersion, which can be implemented cost-effectively, flexibly adapted to the particular optical communication

system, and which also allows for dynamic fluctuations with respect to the birefringence. Exemplary embodiments of the present invention are further directed to providing a suitable optical communication system in part which may effect the method for reducing the distortion of optical pulses in optical communication systems caused by polarization mode dispersion.

To keep the transmission quality in the optical communication system at an optimal value, the transmission quality is measured, and a signal indicative thereof is applied to a regulating device, which drives a polarization-controlling device to alter the polarization state of the communication-transmitting optical pulses. The regulating device controls the polarization of the optical pulses in such a way that the transmission quality is optimized. A small coupled-out portion of the communication-transmitting luminous flux may be used to determine the transmission quality.

Any transmission device at all, for example, an optical fiber or other optical component, can be composed with respect to its birefringence properties, of a number of double-refracting plates, each of which has a different, statistically varying birefringence, delay and orientation. A double-refracting plate assembly of this kind is characteristic for a specific wavelength and is, therefore, dependent upon the frequency of the incident light.

An actual glass fiber may be constituted of a plate assembly, which is not characterized by a stochastic system (or arrangement) of double-refracting plates, but rather that there is at least one preferred, i.e., substantially constant, birefringence in specific sections of the fiber. This means that the optical properties in the mentioned fiber sections can be specified by a single, thick and/or heavily double-refracting plate. An information signal, which

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propagates within such a section in the sense of an optical pulse and which couples to the same extent into both (intrinsic) polarization states of the substantially constant birefringent fiber member, is split into two pulses of the

5   same intensity, but of orthogonal polarization. Both pulse components exhibit a different group velocity in the medium, so that an especially high distortion, i.e., spreading of the originally injected signal pulse, occurs due to the polarization mode dispersion, which limits the communication

10   transmission rate, in particular.

An exemplary embodiment of the present invention is directed to assuring that the optical pulse propagates within the optical communication system having at least one section with

15   preferred or substantially constant birefringence, in such a way that, in the at least one section, the signal exhibits a polarization which corresponds to one of the two main polarization states of the section, e.g., a fiber member. As a result, the pulse shape may not be broadened during

20   transmission by the section having preferred or substantially constant birefringence. Within the section having preferred birefringence, the optical pulses propagate only in one of the two possible channels, i.e., either in the channel having a high rate of propagation or in the channel having the slow

25   rate of propagation, so that the optical pulses are not thereby split or widened, but only accelerated or delayed. This may have no adverse effect on the transmission rate, since the entire pulse sequence experiences an acceleration or delay. It is, thus, assured that the section of the optical

30   transmission medium which exhibits a preferred or substantially constant birefringence and, therefore, may substantially contribute to the widening of the optical pulses, is "eliminated" with respect to the polarization mode dispersion within the entire communication system. The

35   remaining broadening of the optical pulse may only still be caused by the remaining sections of the communication system,

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which can be described, for example, as a stochastic system or arrangement of thin, double-refracting plates. However, the extent to which these other sections of the communication system cause the optical pulse to widen is much less than the

5   possible distortion of the pulse within the section having preferred or substantially constant birefringence, for the case that the light does not traverse the last-mentioned section in only one of the main polarization states.

10   The exemplary embodiments of the present invention are directed to providing that when the optical pulses are modified by the polarization-controlling device before entering into the optical communication system, such that the section having preferred or substantially constant

15   birefringence is traversed in one of the main polarization states of the section and when only that portion of the optical information signal which is transmitted in one of the main polarization states of the section having preferred or substantially constant birefringence, through this section, is

20   considered for the data transmission. Both cases are based on the elucidated principle of the present invention and, accordingly, are equivalent.

To alter the polarization of the information signal in

25   accordance with the present invention, the polarization-controlling device is driven by the regulating device in such a way that the transmission quality is maximized. This regulated, maximal transmission quality corresponds accordingly, for example, to the case when the

30   optical information signal propagates within the section having preferred or substantially constant birefringence in one of the two main polarization states, or when only that portion of the optical information signal, which this applies to, is considered.

35

Another exemplary embodiment of the present invention is

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directed to providing for repeatedly maximizing the
transmission quality at spaced apart time intervals. The
time-related fluctuations in the magnitude and orientation of
the birefringence, which can have a negative effect on the
5   distortion of the optical pulses can be diminished. These
fluctuations, induced, for example, by temperature
fluctuations in an optical fiber, may have the effect that the
optical pulses no longer traverse the section having preferred
or substantially constant birefringence in one of its main
10   polarization states. By maximizing the transmission quality in
repeated, spaced-apart time intervals, one cancels (or
reverses) the spreading of the optical pulse caused by the
fluctuations.

15   To allow for the variation over time in the polarization state
at the input of the optical communication system, the
polarization-controlling device can be connected upstream from
the communication system. By regulating the
polarization-controlling device, one assures that the section
20   having preferred or substantially constant birefringence is
traversed by the optical pulses in one of the two main
polarization states of the section, in spite of the
birefringence fluctuating over time in magnitude and
orientation within the communication system.
25
To losslessly convert the light into the required polarization
state, the polarization-controlling device can include a $\lambda/4$-,
a $\lambda/2$- and a further $\lambda/4$ delay element, the delay elements
being disposed one behind the other and each being adjustable.
30   Using such a polarization-controlling device, light, for
example light pulses having any polarization state at all, can
be changed into light having a different, desired polarization
state.

35   The polarization-controlling device can also be placed at the
output of the communication system, however. This may simplify

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the control, since the determination of transmission quality, the control, and the polarization-controlling device are implemented at the same location. To consider only that component of the light which has propagated in the section

5   having preferred or substantially constant birefringence in one of the main polarization states, an analyzer may be additionally configured downstream from the polarization-controlling elements.

10   If the analyzer is a linear analyzer, then the polarization-controlling device may be simplified to include only a $\lambda/4$- and a $\lambda/2$-delay element, each being adjustable, i.e., rotatable. Using a polarization-controlling device of this kind, light having any polarization at all- in this case

15   light transmitted in one of its main polarization states through the portion having preferred birefringence - can be changed into light having a linear polarization - in this case light which is polarized in the transmit direction toward the analyzer.

20

The delay elements used can include a liquid crystal element or an electro-optic crystal, depending on the special application involved, for example, depending on the wavelength employed. In embodiments of the present invention, the

25   adjusting elements may be readjusted without a driving mechanism, i.e., electrically. If the control takes place at frequencies which are not too high, simple, mechanically movable controlling elements may also be used.

30   BRIEF DESCRIPTION OF THE DRAWINGS
Figure 1 shows an exemplary embodiment of the present invention where the polarization-controlling element is positioned upstream from the optical communication system.

35   Figure 2 shows an exemplary embodiment of the present invention where the polarization-controlling element is placed

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at the output end of the communication system.

DETAILED DESCRIPTION

The optical communication system having reduced distortion of

5 the optical pulses passing through the system may include an
optical transmission medium that is composed of various
sections. These may include optical components, such as fiber
couplers, switches, amplifiers, and other components, optical
lines or fibers. At least one section of the communication

10 system may exhibit a preferred or substantially constant
birefringence. The optical communication system in accordance
with the present invention may include a device for
determining the transmission quality at the end of the
communication system. This device may generate an output

15 signal which is dependent upon the transmission quality and
which is applied to the input of a regulating device. This
regulating device drives a polarization-controlling device,
through which the optical pulses are transmitted and which is,
therefore, set up, or designed, for altering the polarization

20 of the optical pulses. Functioning in response to the detected
transmission quality of the communication system, the
polarization-controlling device is driven to maximize the
transmission quality; i.e., the various parameters for setting
the controlling elements of the polarization-controlling

25 device continue to be modified until the transmission quality
is optimal and can no longer be improved. The
polarization-controlling element may be regulated so that the
transmission quality is measured; the controlling element is
subsequently slightly reset (or readjusted) in any direction

30 within a parameter space.

The transmission quality may subsequently be measured again.
If the transmission quality has become greater, the regulating
device resets the controlling element further in this

35 direction; otherwise it does so in the opposite direction. If
the transmission quality changes slightly or not at all, then

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the regulating device resets the polarization-controlling element in a direction that is orthogonal to the first direction in the parameter space. This method may lead to a local maximum of the transmission quality in the parameter

5   space of the polarization-controlling element. The method may be repeated in specific intervals, which keeps the transmission quality of the communication system at a high level.

10   To ascertain the transmission quality, one can use the bit error rate, for example. It may be determined using special measuring instruments and indicates, as a ratio, how many read errors occur in a known sequence of transmitted pulses. Another exemplary embodiment of the present invention is

15   directed to providing for the so-called eye pattern to be used as a measure of the transmission quality of the communication system. In addition, the polarization mode dispersion itself can also be used as a measure of the transmission quality. This may only be determined with relatively substantial

20   outlay, as is the case for the bit error rate and the eye diagram. The exemplary embodiment of the present invention may be directed to using the redundancy monitoring employed in many digital transmission methods to obtain a measure of the transmission error and, thus, of the transmission quality in

25   the communication system.

In the case of the redundancy monitoring, the so-called parity information (parity bytes) may be calculated from the payload to be transmitted, and added to the payload. The parity

30   information may be obtained by performing a simple calculation. It is presently defined for optical communication systems having a synchronous digital hierarchy as the remainder from a quotient formed from the payload code and a preset key code. The parity information may be extracted and

35   any data blocks having faulty information at all points on the optical transmission link where digital analysis of the

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signals is possible may be immediately recognized. In contrast
to the bit error rate, the described redundancy monitoring may
only permit one data block error rate to be determined, since
each parity byte has assigned to it one complete data record

5   which, accordingly, may only be checked as a whole. Since
typically, however, in the case of signal distortion, such as
in the case of optical pulse spreading due to polarization
mode dispersion, no so-called burst errors occur, i.e., the
errors are distributed more or less equally over time, the

10   redundancy monitoring and a signal Q derived therefrom as an
input signal may be suited for the regulating device.

Figure 1 depicts an exemplary embodiment of an optical
communication system 1 in accordance with the present

15   invention having reduced distortion of the information signal
propagating through the system. The optical information signal
may be transmitted in the form of optical pulses through a
polarization-controlling element 3, before entering into the
optical transmission medium 5. This optical transmission

20   medium 5 may include various sections 5', 5'', 5''', in the
present example, section 5'' being a section in which a
preferred birefringence occurs. The optical transmission
medium may be constituted of an optical fiber line. The other
sections 5', 5''' exhibit a stochastic distribution with

25   respect to the birefringence. Accordingly, these regions are
able to be characterized by a random arrangement of
double-refracting plates. Behind (or downstream from) the
transmission medium, the optical information signal, for
example an optical pulse, may be incident to a beam splitter

30   7, which couples out a small portion of the
communication-transmitting luminous flux. A detector 8 may
convert the coupled-out portion of the information signal into
an electric signal, which may be applied to a device 2 for
determining the transmission quality of communication system

35   1. By the redundancy monitoring, a signal Q, which is a
measure of the transmission quality, may be generated in

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device 2. This signal may be conducted via a data line 9,
which essentially runs in parallel to optical transmission
medium 5, as an input signal to regulating device 4. In an
embodiment of the present invention, data line 9 may be a

5   spectral channel of optical fiber 5. The regulating device may
drive polarization-controlling device 3 to change the
polarization of information signal I.

To reduce the distortion, for example, the spreading of
10   information signals, such as of the optical pulses, in
response to the detected transmission quality of communication
system 1, polarization-controlling device 3 is driven by
regulating device 2 to maximize the transmission quality. As a
consequence of the above described control, the light in
15   section 5'' exhibiting the preferred or substantially constant
birefringence has a polarization that corresponds to one of
the main polarization states of the section, so that, within
this region, no distortion occurs, i.e., the signal does not
spread. Thus, with respect to the polarization mode
20   dispersion, that region is "eliminated", which otherwise would
substantially contribute to the distortion of the signal.

To compensate for time-related fluctuations of the
birefringence and consequences resulting therefrom, provision
25   may be made for the transmission quality to be repeatedly
maximized at spaced apart time intervals. In this manner, at
any particular point in time, the light within section 5''
having the preferred or substantially constant birefringence
may be always polarized in parallel to one of the main
30   polarization states of the transmission medium section.

Referring Figure 1, the polarization-controlling device 3
includes a $\lambda/4$-, a $\lambda/2$- and a further $\lambda/4$ delay element, these
delay elements being disposed one behind the other and each
35   being adjustable, i.e., rotatable. The three degrees of
freedom of the polarization-controlling device are regulated

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by regulating device 4 in accordance with the method of the present invention. Using the entire polarization-controlling device 3, each desired polarization is able to be converted into another desired polarization. Delay elements can include

5   liquid crystal elements, electro-optic crystals, or mechanically, electromotively or piezoelectrically adjustable delay elements, such as fiber loops.

Figure 2 depicts an embodiment of the present invention, where

10   polarization-controlling device 3 is configured downstream from the communication system which includes transmission medium 5 having at least one section 5'' exhibiting a preferred birefringence. Situated in this specific embodiment downstream from the polarization-controlling device, is an

15   analyzer 6, which may absorb or deflect the signal-spreading or signal-distorting polarization components of the optical information flow, depending on the specific embodiment of the analyzer. A small portion of the information flow is split (or separated) off by beam splitter 7 and supplied to detector 8.

20   Its output signal is fed to a regulating device 2, which generates a signal Q that is a measure indicative of the transmission quality. This signal, in turn, is the input quantity for regulating device 4, which drives polarization-controlling device 3. The analyzer 6 may include

25   a linear polarizer, so that the polarization-controlling element merely needs to still transform any particular polarization state into a fixed, linear polarization state. This may be done using a $\lambda/4$- and a $\lambda/2$-delay element, which are disposed in series (or one behind the other) and are each

30   adjustable, i.e., rotatable.

The polarization-controlling device may be adjusted when the light which, in the fiber member having preferred or substantially constant birefringence, assumed the one main

35   polarization state, may be imaged onto the light having the transmit polarization of the analyzer, whereas the light,

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which assumed the other polarization state, is imaged onto the
light having the blocking polarization state of the linear
polarizer. The light which is imaged onto the transmit
polarization of the analyzer may exhibit the higher intensity
5   portion of the entire signal intensity. Thus, the control unit
may be set up such that, in response to too low optical
intensity of the information flow downstream from the
analyzer, the control unit may switch over to the other main
polarization direction of the section of the communication
10   system, such as fiber member 5", having the preferred or
substantially constant birefringence.

A further exemplary embodiment of the present inventions, in
place of beam splitter 7 and detector 8 in Figures 1 and 2, is
15   directed to providing that the transmission quality be
measured at the same time that the information itself is
detected, directly by the main detector at the output of the
transmission link.

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ABSTRACT OF THE DISCLOSURE

A method and device for reducing the distortion of optical
pulses caused by the polarization mode dispersion in optical
communication systems is provided. When an optical pulse
having any polarization is transmitted through an optical
communication system, which is optically anisotropic, at least
in sections, the optical pulse may become distorted due to the
different velocities of the various polarization components.
This distortion of the optical pulses may reduces the maximum
transmission rate of the system. A method is provided for
functioning in response to the detected transmission quality
of the communication system where a polarization-controlling
device for setting the polarization of the optical pulse is
driven in such a way that the transmission quality is
maximized. An optical communication system, including an
optical transmission medium, involves a device for determining
the transmission quality of the communication system, a
regulating device, and a polarization-controlling device. The
output signal from the device for determining the transmission
quality of the communication system may be applied to the
regulating device, which drives the polarization-controlling
device to change the polarization of the optical pulses in
such a way that the transmission quality is optimized.

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REDUCING THE DISTORTION OF OPTICAL PULSES CAUSED BY POLARIZATION MODE DISPERSION IN OPTICAL COMMUNICATION SYSTEMS

The present invention relates to a method for reducing the distortion of optical pulses in optical communication systems, as recited in Claim 1, and to an optical communication system having reduced spreading of the optical pulses propagating

5   through the system, as recited in Claim 5.

In optical communications, optical components, such as optical elements and glass fibers are often used, which are only isotropic in the first approximation, or which are innately

10   anisotropic. For example, the glass fibers employed in photonic networks generally exhibit optical anisotropies due to the manufacturing process and design or due to other circumstances, such as temperature and pressure fluctuations, as well as because of the bending of the fiber itself. These,

15   in part, location-dependent anisotropies also produce an optical birefringence, which can also vary from location to location in the fiber. The birefringence causes two orthogonally polarized natural waves of the light to propagate at different phase velocities in one fiber section under

20   consideration. This means that, in the general case when an optical signal, in particular an optical pulse having any polarization at all, is transmitted through the fiber, the optical pulse becomes distorted, i.e., spreads during the course of propagation, due to the difference in the velocity

25   of the various polarization components. This spreading of the optical pulses limits, in particular, the transmission rate in the communication system.

The object of the present invention is to provide a method for

30   reducing the distortion of optical pulses in optical communication systems caused by polarization mode dispersion, which can be implemented cost-effectively, flexibly adapted to

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the particular optical communication system, and, in particular, which also allows for dynamic fluctuations with respect to the birefringence. A further aim is to provide a suitable optical communication system, which will not have the

5   mentioned disadvantages of the related art systems.

This technical objective is achieved by the present invention, on the one hand, by the method steps which include the features of Claim 1 and, on the other hand, by the features of

10   Claim 5.

To keep the transmission quality in the optical communication system at an optimal value, the transmission quality is measured, and a signal indicative thereof is applied to a

15   regulating device, which drives a polarization-controlling device to alter the polarization state of the optical pulses. The regulating device controls the polarization of the optical pulses in such a way that the transmission quality is optimized.

20

Generally, any transmission device at all, for example an optical fiber or other optical component, can be produced with respect to its birefringence properties, from a number of double-refracting plates, each of which has a different,

25   statistically varying birefringence, delay and orientation. A double-refracting plate assembly of this kind is characteristic for a specific wavelength and is, therefore, dependent upon the frequency of the incident light.

30   The present invention is based on the realization that, for example, an actual glass fiber is generally constituted of a plate assembly, which is not characterized by a stochastic system of double-refracting plates, but rather that there is at least one preferred, i.e., substantially constant

35   birefringence in specific sections of the fiber. This means that the optical properties in the mentioned fiber sections can be specified by a single, thick and/or heavily

double-refracting plate. An information signal, which
propagates within such a section in the sense of an optical
pulse and which couples to the same extent into both
(intrinsic) polarization states of the preferably birefringent
fiber member, is split into two pulses of the same intensity,
but of orthogonal polarization. Both pulse components exhibit
a different group velocity in the medium, so that an
especially high distortion, i.e., spreading of the originally
injected signal pulse, occurs due to the polarization mode
dispersion, which limits the communication transmission rate,
in particular.

The underlying principle of the present invention is to assure
that the optical pulse propagates within the optical
communication system having at least one section with
preferred birefringence, in such a way that, in the mentioned
section, the signal exhibits a polarization which corresponds
to one of the two main polarization states of the section, for
example of a fiber member. As a result, the pulse shape is not
broadened during transmission by the section having preferred
birefringence. Within the section having preferred
birefringence, the optical pulses propagate only in one of the
two possible channels, i.e., either in the one having a high
rate of propagation or in the one having the slow rate of
propagation, so that the optical pulses are not thereby split
or widened, but only accelerated or delayed. However, this has
no adverse effect on the transmission rate, since the entire
pulse sequence experiences an acceleration or delay. It is,
thus, assured that the section of the optical transmission
medium which exhibits a preferred birefringence and,
therefore, can substantially contribute to the widening of the
optical pulses, is "eliminated" with respect to the
polarization mode dispersion within the entire communication
system. Thus, the remaining broadening of the optical pulse is
only still caused by the remaining sections of the
communication system, which can be described, for example, as
a stochastic system of thin, double-refracting plates.

However, the extent to which these other sections of the
communication system cause the optical pulse to widen is much
less than the possible distortion of the pulse within the
section having preferred birefringence, for the case that the
5   light does not traverse the last-mentioned section in only one
of the main polarization states.

The above explanations apply, on the one hand, for the case
when the optical pulses are modified by the
10   polarization-controlling device before entering into the
optical communication system, such that the section having
preferred birefringence is traversed in one of the main
polarization states of the section and, on the other hand,
also applies to the case when only that portion of the optical
15   information signal which is transmitted in one of the main
polarization states of the section having preferred
birefringence, through this section, is considered for the
data transmission. Both cases are based on the elucidated
principle of the present invention and, accordingly, are
20   equivalent.

To alter the polarization of the information signal in
accordance with the present invention, the
polarization-controlling device is driven by the regulating
25   device in such a way that the transmission quality is
maximized. This regulated, maximal transmission quality
corresponds accordingly, for example, to the case when the
optical information signal propagates within the section
having preferred birefringence in one of the two main
30   polarization states, or when only that portion of the optical
information signal, which this applies to, is considered.
One advantageous specific embodiment of the present invention
provides for repeatedly maximizing the transmission quality at
spaced apart time intervals. This makes it possible to
35   diminish the time-related fluctuations in the magnitude and
orientation of the birefringence, which can have a negative
effect on the distortion of the optical pulses. These

fluctuations, mentioned already above, induced, for example, by temperature fluctuations in an optical fiber, can have the effect that the optical pulses no longer traverse the section having preferred birefringence in one of its main polarization states. By maximizing the transmission quality in repeated, spaced-apart time intervals, one cancels the spreading of the optical pulse caused by the fluctuations.

To allow for the variation over time in the polarization state at the input of the optical communication system, the polarization-controlling device can be connected upstream from the communication system. By regulating the polarization-controlling device, one assures that the section having preferred birefringence is traversed by the optical pulses in one of the two main polarization states of the section, in spite of the birefringence fluctuating over time in magnitude and orientation within the communication system.

To losslessly convert the light into the required polarization state, the polarization-controlling device can include a $\lambda/4$-, a $\lambda/2$- and a further $\lambda/4$ delay element, the delay elements being disposed one behind the other and each being adjustable. Using such a polarization-controlling device, light, for example light pulses having any polarization state at all, can be changed into light having a different, desired polarization state.

The polarization-controlling device can also be placed at the output of the communication system, however. This simplifies the control, since the determination of transmission quality, the control, and the polarization-controlling device are implemented at the same location. To consider only that component of the light which has propagated in the section having preferred birefringence in one of the main polarization states, an analyzer is additionally configured downstream from the polarization-controlling elements.

If this analyzer is a linear analyzer, then the polarization-controlling device is simplified to the effect that it includes only a $\lambda/4$- and a $\lambda/2$-delay element, which are each adjustable, i.e., rotatable. Using a

5   polarization-controlling device of this kind, light having any polarization at all- in this case light transmitted in one of its main polarization states through the portion having preferred birefringence - can be changed into light having a linear polarization - in this case light which is polarized in

10   the transmit direction toward the analyzer.
In both the arrangements that make use of the principle of the present invention, as well as in the method, the delay elements used can include a liquid crystal element or an electrooptic crystal, depending on the special application

15   involved, for example depending on the wavelength employed. The advantage of these adjusting elements is that they can be readjusted without a driving mechanism, i.e., electrically. If the control takes place at frequencies which are not too high, simple, mechanically movable controlling elements can also be

20   used.

The present invention is described in the following on the basis of a few exemplary embodiments, reference being made to the drawing, whose figures show:

25   Figure 1   one specific embodiment of the present invention, where the polarization-controlling element is positioned upstream from the optical communication system; and
Figure 2   one specific embodiment of the present invention,

30   where the polarization-controlling element is placed at the output end of the communication system.
/

In accordance with the present invention, the optical communication system having reduced distortion of the optical

35   pulses passing through the system includes an optical transmission medium that is composed of various sections. These can include optical components, such as fiber couplers,

switches, amplifiers, and other components, but also optical
lines (fibers). At least one section of the communication
system exhibits a preferred birefringence. In addition, the
optical communication system in accordance with the present
5   invention includes a device for determining the transmission
quality at the end of the communication system. This device
generates an output signal which is dependent upon the
transmission quality and which is applied to the input of a
regulating device. This regulating device drives a
10   polarization-controlling device, through which the optical
pulses are transmitted and which is, therefore, set up for
altering the polarization of the optical pulses. Functioning
in response to the detected transmission quality of the
communication system, the polarization-controlling device is
15   driven to maximize the transmission quality; i.e., the various
parameters for setting the controlling elements of the
polarization-controlling device continue to be modified until
the transmission quality is optimal and can no longer be
improved. In particular, the polarization-controlling element
20   is regulated to the effect that the transmission quality is
measured; the controlling element is subsequently slightly
reset in any direction within a parameter space.

The transmission quality is subsequently measured once again.
25   If the transmission quality has become greater, the regulating
device resets the controlling element further in this
direction; otherwise in the opposite direction. If the
transmission quality changes slightly or not at all, then the
regulating device resets the polarization-controlling element
30   in a direction that is orthogonal to the first in the
parameter space. This method leads to a local maximum of the
transmission quality in the parameter space of the
polarization-controlling element. The method is repeated in
specific intervals, which keeps the transmission quality of
35   the communication system at a high level.

To ascertain the transmission quality, one can use the bit

error rate, for example. It is determinined using special
measuring instruments and indicates, as a ratio, how many read
errors occur in a known sequence of transmitted pulses.
Another specific embodiment of the present invention provides

5   for the so-called eye pattern to be used as a measure of the
transmission quality of the communication system. In addition,
the polarization mode dispersion itself can also be used as a
measure of the transmission quality. However, this can only be
determined with relatively substantial outlay, as is the case

10   for the bit error rate and the eye diagram. For that reason,
most specific embodiments of the present invention make use of
the redundancy monitoring employed in many digital
transmission methods to obtain a measure of the transmission
error and, thus, of the transmission quality in the

15   communication system.

In the case of the redundancy monitoring, the so-called parity
information (parity bytes) are calculated from the payload to
be transmitted, and added to the payload. The parity

20   information is obtained by performing a simple calculation. It
is presently defined for optical communication systems having
a synchronous digital hierarchy as the remainder from a
quotient formed from the payload code and a preset key code.
One can extract the parity information and immediately

25   recognize data blocks having faulty information at all points
on the optical transmission link where digital analysis of the
signals is possible. In contrast to the bit error rate, the
described redundancy monitoring only permits one data block
error rate to be determined, since each parity byte has

30   assigned to it one complete data record which, accordingly,
can only be checked as a whole. Since typically, however, in
the case of signal distortion, i.e., in the case of optical
pulse spreading due to polarization mode dispersion, no
so-called burst errors occur, i.e., the errors are distributed

35   more or less equally over time, the redundancy monitoring and
a signal Q derived therefrom as an input signal are suited for
the regulating device.

Figure 1 depicts an exemplary specific embodiment of an
optical communication system 1 in accordance with the present
invention having reduced distortion of the information signal
propagating through the system. The optical information signal
is transmitted in the form of optical pulses through a
polarization-controlling element 3, before entering into the
optical transmission medium 5. This optical transmission
medium 5 includes various sections 5', 5'', 5''', in the
present example, section 5'' being a section in which a
preferred birefringence occurs. In the present instance, the
optical transmission medium is constituted of an optical fiber
line. The other sections 5', 5''' exhibit a stochastic
distribution with respect to the birefringence. Accordingly,
these regions are able to be characterized by a random
arrangement of double-refracting plates. Behind the
transmission medium, the optical information signal, for
example an optical pulse, is incident to a beam splitter 7,
which couples out a small portion of the
communication-transmitting luminous flux. A detector 8
converts the coupled-out portion of the information signal
into an electric signal, which is applied to a device 2 for
determining the transmission quality of communication system
1. By way of the above described redundancy monitoring, a
signal Q, which is a measure of the transmission quality, is
generated in device 2. This signal is conducted via a data
line 9, which essentially runs in parallel to optical
transmission medium 5, as an input signal to regulating device
4. In one specific embodiment of the present invention, data
line 9 is a spectral channel of optical fiber 5. The
regulating device drives polarization-controlling device 3 to
change the polarization of information signal I.

To reduce the distortion, for example the spreading of
information signals, i.e., of the optical pulses, in response
to the detected transmission quality of communication system
1, polarization-controlling device 3 is driven by regulating
device 2 to maximize the transmission quality. As a

consequence of the above described control, the light in
section 5'' exhibiting the preferred birefringence has a
polarization that corresponds to one of the main polarization
states of the section, so that, within this region, no
5   distortion occurs, i.e., the signal does not spread. Thus,
with respect to the polarization mode dispersion, that region
is "eliminated", which otherwise would substantially
contribute to the distortion of the signal.

10   To compensate for time-related fluctuations of the
birefringence and consequences resulting therefrom, provision
is made for the transmission quality to be repeatedly
maximized at spaced apart time intervals. In this manner, at
any particular point in time, the light within section 5''
15   having the preferred birefringence is always polarized in
parallel to one of the main polarization states of the
transmission medium section.

The polarization-controlling device 3 in Figure 1 includes a
20   $\lambda/4$-, a $\lambda/2$- and a further $\lambda/4$ delay element, these delay
elements being disposed one behind the other and each being
adjustable, i.e., rotatable. The three degrees of freedom of
the polarization-controlling device are regulated by
regulating device 4 in accordance with the above method. Using
25   the entire device 3, each desired polarization is able to be
converted into another desired polarization. Delay elements
can include liquid crystal elements, electrooptic crystals, or
mechanically, electromotively or piezoelectrically adjustable
delay elements, such as fiber loops.
30
Figure 2 depicts one specific embodiment of the present
invention, where polarization-controlling device 3 is
configured downstream from the communication system which
includes transmission medium 5 having at least one section 5''
35   exhibiting a preferred birefringence. Situated in this
specific embodiment downstream from the
polarization-controlling device, is an analyzer 6, which

absorbs or deflects the signal-spreading or signal-distorting polarization components of the optical information flow, depending on the specific embodiment of the analyzer. A small portion of the information flow is split off by beam splitter

5   7 and supplied to detector 8. Its output signal is fed to a regulating device 2, which generates a signal Q that is a measure of the transmission quality. This signal, in turn, is the input quantity for regulating device 4, which drives polarization-controlling device 3. In the described specific

10 embodiment of the present invention, analyzer 6, as described above, includes a linear polarizer, so that the polarization-controlling element merely needs to still transform any particular polarization state into a fixed, linear polarization state. This can be done using a $\lambda/4$- and a

15 $\lambda/2$-delay element, which are disposed in series and are each adjustable, i.e., rotatable.

The polarization-controlling device is optimally adjusted when the light which, in the fiber member having preferred

20 birefringence, assumed the one main polarization state, is imaged onto the light having the transmit polarization of the analyzer, whereas the light, which assumed the other polarization state, is imaged onto the light having the blocking polarization state of the linear polarizer. The light

25 which is imaged onto the transmit polarization of the analyzer should preferably exhibit the higher intensity portion of the entire signal intensity. For this reason, the control unit is set up such that, in response to too low optical intensity of the information flow downstream from the analyzer, it switches

30 over to the other main polarization direction of the section of the communication system, preferably fiber member 5", having the preferred birefringence.

In place of beam splitter 7 and detector 8 in Figures 1 and 2,

35 another specific embodiment of the present invention provides that the transmission quality be measured at the same time that the information itself is detected, directly by the main

detector at the output of the transmission link.

What is claimed is:

1. A method for reducing the distortion of optical pulses
   (I) in an optical communication systems (1) caused by
   polarization mode dispersion,
   wherein, functioning in response to the detected
   transmission quality of the communication system, a
   polarization-controlling device (3) for adjusting the
   polarization of the optical pulse is driven in such a way
   that the transmission quality is maximized.

2. The method as recited in Claim 1,
   wherein, to optimize the communication, the polarization
   is reset in predefined time intervals.

3. The method as recited in Claim 1 or 2,
   wherein the polarization of the optical signal (I) is
   controlled at the beginning of the optical communication
   system.

4. The method as recited in Claim 1 or 2,
   wherein, using the polarization-controlling device (3),
   the polarization of the optical pulses is altered at the
   end of the optical communication system (5), and,
   following the optical communication system, the signal
   (I) propagates through an analyzer (6).

5. An optical communication system (1) having reducible
    distortion of the optical pulses propagating through the
    system, for implementing the method as recited in one of
    the Claims 1 through 4, comprising
    —   an optical transmission medium;
    —   a device (2) for determining the transmission
         quality of the communication system, whose output
         signal is applied to the input
    —   of a regulating device (4), which drives a
    —   polarization-controlling device (3) for changing the
         polarization of the optical pulses such that the
         transmission quality is optimized.

6. The optical communication system as recited in Claim 5,
    wherein the polarization-controlling device (3) is
    positioned at the input of the transmission medium.

7. The optical communication system as recited in Claim 5,
    wherein the polarization-controlling device (3) is
    positioned at the output of the transmission medium and,
    in addition, an analyzer (6) is positioned in the
    propagation direction of the light, downstream from the
    polarization-controlling device (3).

8. The optical communication system as recited in one of the
    Claims 5 through 7,
    wherein the polarization-controlling device (3) includes
    a $\lambda/4$ delay element, a $\lambda/2$ delay element and a further
    $\lambda/4$ delay element, the delay elements being situated in
    this sequence, in series, and each being adjustable.

9. The optical communication system as recited in Claim 7,
    wherein the analyzer (6) is a linear analyzer, and the
    polarization-controlling device (3) includes a $\lambda/4$- and a
    $\lambda/2$-delay element, which are adjustable.

10. The optical communication system as recited in one of the
    preceding Claims 5 through 9,
    wherein at least one delay element includes a liquid
    crystal element.

11. The optical communication system as recited in one of the
    preceding Claims 5 through 10,
    wherein at least one delay element includes an
    electro-optical crystal.

12. The optical communication system as recited in one of the
    preceding Claims 5 through 11,
    wherein at least one delay element includes a
    mechanically, electromotively or piezoelectrically
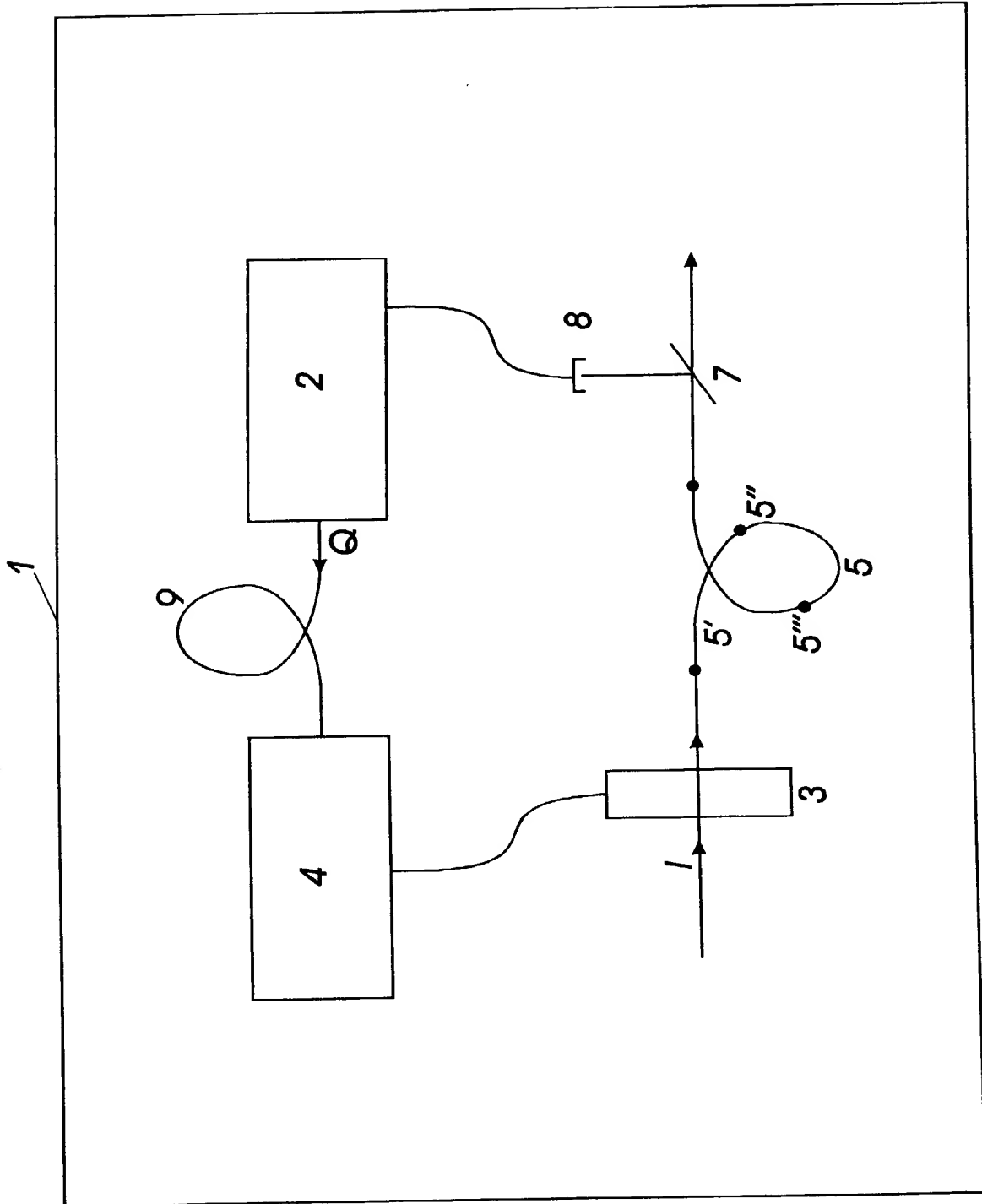   adjustable element of three fiber loops.

Abstract

Reducing the distortion of optical pulses caused by the polarization mode dispersion in optical communication systems.

5

When an optical pulse having any polarization at all is transmitted through an optical communication system, which is optically anisotropic, at least in sections, the optical pulse generally becomes distorted due to the different velocities of

10   the various polarization components. This distortion of the optical pulses reduces, in particular, the maximum transmission rate of the system.

A remedy is provided, on the one hand, by a method where,

15   functioning in response to the detected transmission quality of the communication system, a polarization-controlling device for setting the polarization of the optical pulse is driven in such a way that the transmission quality is maximized and, on the other hand, by an optical communication system, which

20   includes an optical transmission medium, a device for determining the transmission quality of the communication system, a regulating device, and a polarization-controlling device. The output signal from the device for determining the transmission quality of the communication system is applied to

25   the regulating device, which drives the polarization-controlling device to change the polarization of the optical pulses in such a way that the transmission quality is optimized.
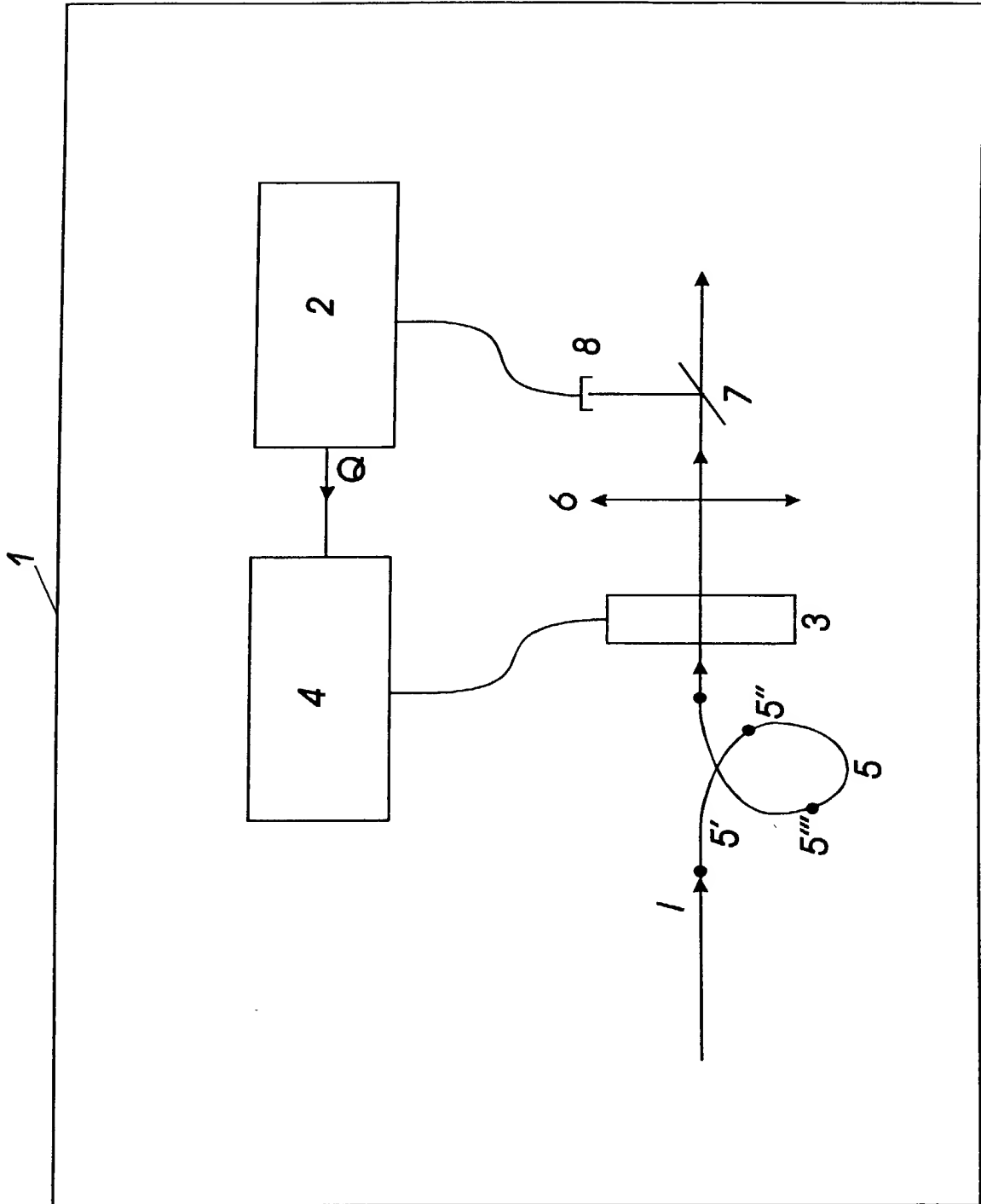
Fig. 1

Fig. 2

DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled **REDUCTION OF THE DISTORTION OF OPTICAL IMPULSES THROUGH POLARISATION MODE DISPERSION IN OPTICAL TRANSMISSION SYSTEMS**, the specification of which was filed as International Application No. PCT/EP00/00320 on January 17, 2000 and filed as a U.S. application having Serial No. 09/890597 on August 3, 2001 for Letters Patent in the U.S. Patent and Trademark Office.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, § 1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, § 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application(s) for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

PRIOR FOREIGN APPLICATION(S)

Number	Country Filed	Day/Month/Year	Priority Claimed Under 35 USC 119
199 04 137.7	Fed. Rep. of Germany	February 3, 1999	Yes

And I hereby appoint Richard L. Mayer (Reg. No. 22,490), Gerard A. Messina (Reg. No. 35,952) and Linda M. Shudy (Reg. No. 47,084) my attorneys with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith.

Please address all communications regarding this application to:

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New York, New York 10004

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Please direct all telephone calls to Richard L. Mayer at (212) 425-7200.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful and false statements may jeopardize the validity of the application or any patent issued thereon.

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Inventor: **Leonid BERESNEV**

Inventor's Signature: x _____

Date: x February 23, 2002

Residence: 10730 Faulkner Ridge Circle
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Inventor: **Erna FRINS**

Inventor's Signature: _~~~~~_

Date: _27. February, 2002_

Residence: Sepée 1748, Casa 6
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Inventor: **Franko KUEPPERS**

Inventor's Signature: *[signature]*

Date: *March 2, 2002*

Residence: Pupinweg 3
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Inventor: **Heidrun SCHMITZER**

Inventor's Signature: _Dr. H. Schmitzer_

Date: _25. February 2002_

Residence: Am Feld 29
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Citizenship: German

Office Address: Same as above.

Inventor: **Joachim VOBIAN**

Inventor's Signature: _~Joachim Vobian~_

Date: _05th March 2002_

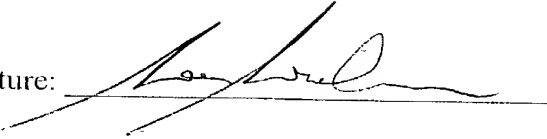Residence: Am Hang 6
D-64367 Muehltal
Federal Republic of Germany   _DEX_

Citizenship: German

Office Address: Same as above.

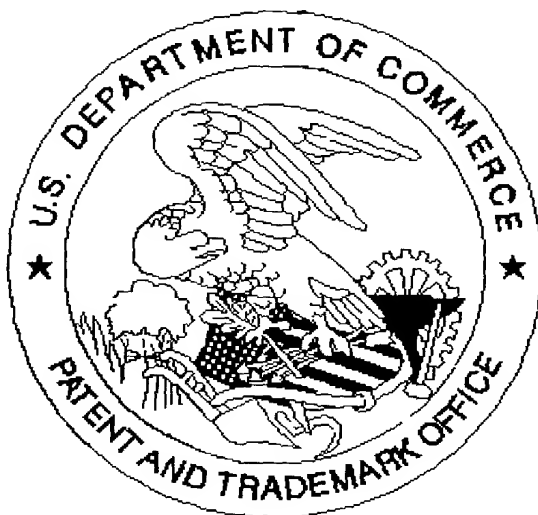Inventor: **Werner WEIERSHAUSEN**

Inventor's Signature: _____

Date: _8. 4. 2002_

Residence: Alte Darmstaedter Str. 17
D-64367 Muchltal
Federal Republic of Germany *DEX*

Citizenship: German

Office Address: Same as above.

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